Available online at www.sciencedirect.com

SciVerse ScienceDirect

Energy Procedia 9 (2011) 238 – 244

Energy Procedia

9th Eco-Energy and Materials Science and Engineering Symposium

Thermal efficiency improvement and technology transfer of chimney stove for producing stove; Amphoe Bo Kluea, Nan Province

Yutana Sriudom[a*]

[a]*Department of Mechanical Engineering, Faculty of Engineering*
Rajamangala University of Technology Lanna Tak, Tak 63000, Thailand

Abstract

Salt production by evaporation of brine drawn from deep wells in of Bo Kluea District, Nan, has been carried out for many centuries by using traditional wood-based stoves. This study aims to improve thermal efficiency of traditional stoves, while tradition stove structures and salt making methods were maintained. The prototype and tradition stove were compared by thermal efficiency method. The tradition stove was constructed with clay. The prototype chimney stoves have been making from brick plastered with cement. The prototype chimney stove was insulated by filling rich hush in the gap of stove wall which has 3 cm. thicknesses and the end of the chimney. The stove can put 2 pans. Eucalyptus woods were used be fuel for testing the thermal efficiency. The prototype stove increases thermal efficiency approximately by 5.3 percents form normally 9.6 percents. This is achieved by using carbonized rice husk as stove insulating materials to reduce heat loss through stove walls. Salt production cycles are decreased by 25 minutes from 4.5 - 5 hours and the rate of fuel per day decreased 14 - 15 kilograms from 257 kg of firewood. Costs to improve salt production stoves 1,545 THB have a Pay-back period 107 days. The improved prototype chimney stove can help to decrease fuel costs and increase the salt production rate. This research is not only saving energy but also keep tradition of local living.

Selection and/or peer-review under responsibility of CEO of Sustainable Energy System,
Rajamangala University of Technology Thanyaburi (RMUTT).

Keywords: Salt, Thermal efficiency, Stove, Eucalyptus wood, Pay-back period;

* Corresponding author. Tel.: +66-455-515-900-5; fax: +66-455-511-833.
E-mail address: num_kmutt@hotmail.com

doi:10.1016/j.egypro.2011.09.025

1. INTRODUCTION

"Salt pit" This is rock salt by boiling salt of people still using traditional stove was constructed with clay. The stove can put 2 pans. Eucalyptus woods were used be fuel. Salt production cycles are 4.5 - 5 hours. Currently wood fuel is decreased because of the increasing operator by most of the wood fuel purchased from nearby village and relatively high price. So it is necessary to use the energy to maximum benefit.

Development of the stove for improvement thermal efficiency by reducing heat loss through the walls. It can reduce energy consumption of wood fuel, this is important in reducing the cost of salt producing and also to optimize energy consumption. This research is to study improve thermal efficiency and design a salt producing stove by reducing heat loss through the wall and the use of energy efficient and appropriate.

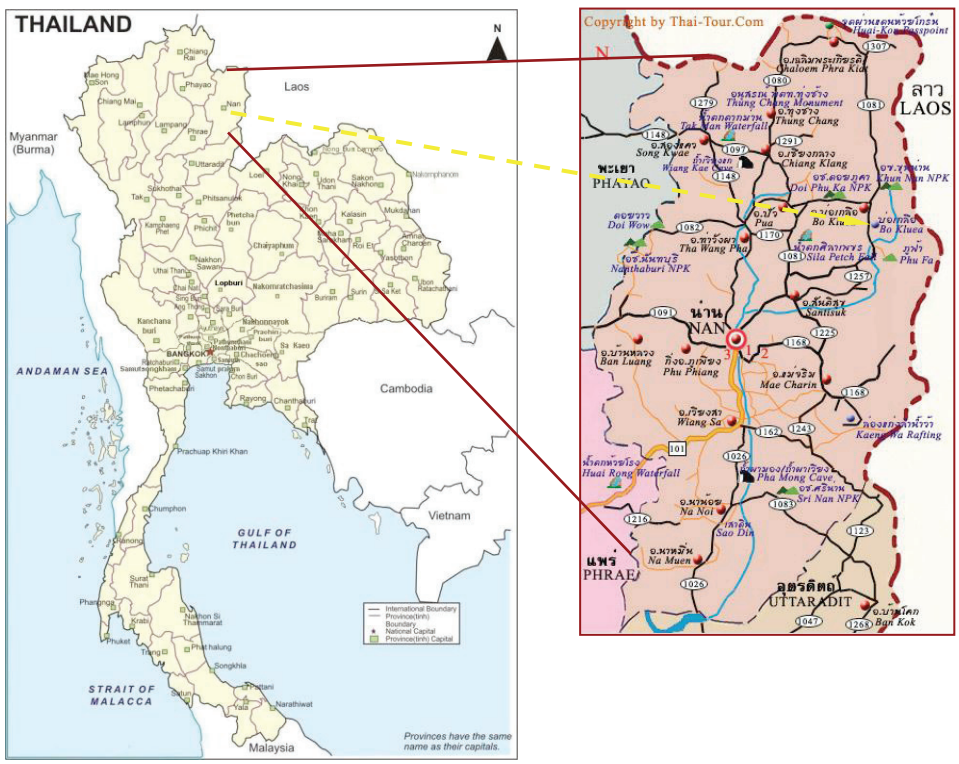

Fig.1. Map showing the location of establishment salt producing stove.

2. METHODOLOGY

2.1. Conceptual design

Combustion systems design to appropriated wood fuel but still keep the appropriate energy and lowest cost improvement by continuing to heat as needed. The prototype chimney stoves have been making from brick plastered with cement. The tradition stove was insulated by filling rich hush in the gap of stove wall which has 3 cm. thicknesses and stove rear install the chimney. The stove can put 2 pans.

Fig. 2. (a) Tradition stove; (b) Prototype Chimney Stove.

2.2. Material and Method

1. Materials
   1.1 Scale size 100-500 grams and 0.1 – 15 kilograms.
   1.2 Thermocouples Type K, IEC standard 584, rang of Temperature –270 ºC to +1,370 ºC
   1.3 Data Logger Campbell 21x

Fig.3. Data Logger Campbell 21x.

1.4 Fluke Ti25 Thermal Imagers

Fig.4. Fluke Ti25 Thermal Imagers.

2. Method of data collection.
   2.1 Surveys and collect data base of Salt production process of tradition stove.
   2.2 Test and analyze test results of tradition stove and prototype stove chimney.
   2.3 Training/Workshop and technology transfer to the entrepreneurs.

2.3. Thermal Efficiency

In a Water Boiling Test, a known quantity of water is heated on the Salt Producing Stove. No lid is used to cover the wok so that evaporated water freely escapes from the wok. The quantity of water evaporated after complete burning of the fuel is determined to calculate the thermal efficiency by using the Equation *(1)*

Formula for thermal efficiency

$$\frac{\left[\left(M_W C_W \left(T_b - T_o\right)\right) + \left(M_s L_W\right)\right]}{\left(M_{firewood} HV_{firewood}\right)} 100,\% \quad (1)$$

When:

M_W Initial weight of water, kg

C_W Specific heat of water, kJ/kg ºC

T_b Boiling point of water, ºC

T_o Water temperature start, ºC

M_s Mass of water evaporated, kg

L_W Latent heat of water, kJ/kg

$M_{firewood}$ Mass of wood fuel used, kg

$HV_{firewood}$ Heating value of wood fuel, kJ/kg

2.4. Analysis of economic

The cost of investment to improve salt producing stove the payback period analysis by using Equation *(2)*

Payback period = net revenue /Cost of project (2)

3. RESULTS AND DISCUSSION

3.1. Process of salt Producing

1. Dip brine from salt well to stay in the saline reservoir.

Fig.5. Salt well and saline reservoir.

2. Dip brine from the reservoir and add 2 pans ranges to fill pans.
3. Fires using wood fuel and wood from time to refuel.
4. When the salt starts dry. Use spatula to scoop the salt and set aside in basket and leave it until dry salt. By approximately 4 to 5 hours. (Salt has an average 14 to 15 kg /wok)
5.

Fig.6. Showed salt starts dry and set aside in basket.

6. After drying salt. It will move aside in to storage. Waiting for packaging and distribution.
7.

Fig.7. Showed storage and packaging.

3.2. Results of Survey data on the amount of firewood for salt producing

The survey volume of wood fuel found that the ratio of wood fuel on average 245 to 260 kg/wok/day or 68 – 70 ton/wok/year or ton of Oil Equivalent 31.17 toe.

3.3. Result of testing of Salt Producing Stove

Fig .8. (a) The results of measuring the temperature at the wall Prototype Chimney Stove wall ; (b) Fig .9. The results of measuring the temperature at the wall of tradition stove wall

Figs. 9 and 10 show average temperature at the wall of the Prototype chimney stove and Tradition stove. Found that the average temperature at the wall of the Prototype chimney stove lower than traditional stove.

3.4. Result of testing and analysis of Salt producing stove

Table 1. Analysis of test salt producing stove.

	Prototype Chimney Stove	Tradition Stove
Water temperature start, ºC	22	22
Boiling point of water, ºC	97	97
Average temperature of outer stove wall, ºC	43.89	56.11
Average temperature of inside stove wall, ºC	361.67	358.89
Average ground temperature 10 cm deep, ºC	35.43	38.89
Average exhaust temperature, ºC	163.69	291.11
Thermal efficiency, %	14.9	9.6

3.5. Result analysis of economics.

Table 2. Analysis of economic.

	Prototype Chimney Stove	Tradition Stove
Cost of Project, THB	1,545	~300
Rate of Wood Fuel, kg/day	246	260
Costs of wood Fuel, THB/day	1.03	1.03
Save Cost of Wood Fuel, THB/day	14.43	-
Payback period, day	107	-
Lifetime, year	3	1

4. Conclusion

Results from testing a prototype chimney stove by using carbonized rice husk as stove insulating to reduce heat loss through stove walls found that it can reduce wood fuel consumption to 5 kg/cycle. The prototype stove increases thermal efficiency approximately by 5.3 percents form normally 9.6 percents. Reduce cost of wood fuel 14 THB/day. Salt production cycles are decreased by 25 minutes from 4.5 - 5 hours and the rate of fuel per day decreased 14 - 15 kilograms from 257 kg of firewood consumption to be 14-15 kg/Stove/day or 4.1 tons/Stove/year or ton of Oil Equivalent 1.55 toe. Currently prototype stove uses 2 stove. Costs to improve salt production stoves 1,545 THB have a Pay-back period 107 days.

Acknowledgements

The research is conducted respectfully request thank Office of the National Research Council of Thailand. Research support for the operation until the completion of this study went well. Thank Department of Pilot Plant Development and Training Institute, King Mongkut's Universtity of Technology Thonburi to the generosity of tools for data collection. Thank Associate professor Dr. Suvit Tia for advice and guidance to solve the various problems as well as assistance in all aspects of doing research.

References

[1] Erick Boy and Et al. 2006. Fuel efficiency of an improved wood-burning stove in rural Guatemala: implications for health, environment and development, Energy for Sustainable Development l, Volume IV No. 2 l.

[2] John, P. McCracken and Kirk, R. Smith. 1998. Emissions and efficiency of improved wood burning cook stoves in Highland Guatemala, Environmental Health Sciences,. MC-7360, University of California, Berkeley, CA 94720, USA.

[3] Karabi Duttaa and Et al. 2009. Impact of improved biomass cook stoves on indoor air quality near Pune India, Energy for Sustainable Development, Volume 11, Issue 2, June 2007.

[4] Yutana, S. 2011. Thermal Efficiency Improvement of Salt Producing Stove at Amp Phur Bo Kluea, Nan Province. International conference for a sustainable greater Mekong subregion, August 2010.